Space Weather Technical Forecast

Issued on Tuesday, 17 September 2024 at 13:41 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: CME arrived late 16 Sep. G1-G2 geomagnetic storms Expected Day 1 (17 Sep), activity declining by Day 2. Ongoing S1/Minor Radiation Storm, Chance this continues into Day 2. Ongoing Chance of M-class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity measured at GOES16 and 18 was Low, with mainly mid-range C-class x-ray flares observed other than a peak of C9.6 at 16/2356 UTC from AR3825 in the southeast. There are currently nine sunspot regions on the visible disc, two of which are unnumbered. The main changes in the period were seen in the two most complex regions on the disc. AR3825, in the southeast, remains the largest and most complex region on the disc and saw the proliferation of small spots within the sunspot group and the emergence of a delta configuration in its trail portion. AR3825 remains perhaps the most noteworthy group due to its history of X-class activity. The other region of note is AR3824, in the southwest, which saw consolidation of a number of spots with the large lead spot. Although some small regions have emerged during the past 24 hours, the remaining unmentioned regions are relatively stable and unchanged since last analysis, and are either simple dipoles or unipolar.

No Earth-directed Coronal Mass Ejections (CMEs) were in evidence in the period. One CME seen leaving the Sun late on 16 Sep is yet to be analysed, but is considered to be far-sided due to lack of evidence in near-side SDO imagery.

Solar Wind / Geomagnetic Activity: Solar wind parameters, as observed by ACE at L1, showed ongoing slightly elevated solar wind speeds around 450 km/s. However, at 16/2250UTC a CME arrival resulted in a sudden rise in winds to around 520-550 km/s with the CME shock then hitting Earth and producing a change in the BGS Hartland magnetometer H component of 35nT in three minutes from 16/2329UTC. Wind speeds have since remained mostly Elevated, but have fallen to around 500-520 km/s in recent hours.

The steady positive phi angle (away from the Sun) prior to this arrival may indicate connection to a positive coronal hole, perhaps CH69/+ in the southwest. This may be back-dated to onset around 14 September, where a slight increase in solar wind speed and decrease in solar wind density was observed.

The solar wind density was below average, with a slight uptick at the CME arrival time. The IMF was weak to moderate, before suddenly jumping upon CME arrival to above average with a peak of 20nT at 17/0137. Levels have since declined but remain just above average. The north-south component fluctuated weakly initially but was largely positive, however, in the wake of the CME shock has since strongly fluctuated and been predominantly negative varying between +7 and -18nT.

The net result of the above solar wind measures was a peak G4/Severe Geomagnetic Storm (Kp 8) interval before gradually declining to current G1/Minor Geomagnetic Storm levels (Kp 5).

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Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux observed by GOES18 was slightly above normal background levels following the X4.5 flare on 14 September. Levels rose to S1/Minor Solar Radiation Storm around 17/0725 UTC and have continued to rise.
High energy electron flux (greater than 2MeV) observed by GOES16, generally varied on a diurnal cycle between Normal Background to High levels, peaking at 2240pfu at 16/1215UTC. Since the arrival of the CME, electron levels have plummeted to background. The associated 24-hour fluence showed a generally flat trend, with 4.3e7 integrated pfu observed at 16/2359UTC.

Four-Day Space Weather Forecast Summary
Solar Activity: Low to Moderate activity is forecast, with a Chance of M-class flares, most likely from AR3824 or AR3825. There is an ongoing Slight Chance of an isolated X-class flare from AR3825. No significant regions are expected to arrive or depart in the period and the risk is deemed largely constant as a result.

Solar Wind / Geomagnetic Activity: The main inbound CME from the X4.5-related CME on 14 September has now arrived (and the 13 September CME which it may have swept up). Further G1/Minor Geomagnetic Storm intervals are expected with a chance of G2 during the UTC afternoon of Day 1 (17 Sep). Earth may also already be encountering one of the forecast coronal holes and this has probably now peaked. A second coronal hole fast wind from CH70/+ may arrive late Day 2 or 3 (18 or 19 Sep), with Slightly Elevated to Elevated speeds possible.
G1-G2/Minor to Moderate Geomagnetic Storm intervals are Expected through Day 1 with activity declining towards Unsettled to Active (Kp 3-4) into Day 2 (18 Sep). The small stature of CH70/+ should mean that activity and enhancement late Day 2 or Day 3 is short-lived, with a Slight Chance of G1 before waning to leave Quiet (Kp 0-2) conditions later in the period.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 is currently at S1/Minor Storm levels. Levels are expected to peak at S1 on Day 1 (17 Sep) before waning during Day 2 (18 Sep) and returning to background Days 3-4. The slight chance of S1 later in the period takes into consideration the potential for enhancement from AR3824 and/or AR3825.
High energy electron flux should continue to show suppression followed by rebound later in the period as a result of the arrived CME(s), but all within Slight Chance of Active 24-hour fluence. CH70/+ not felt likely to be impactful.

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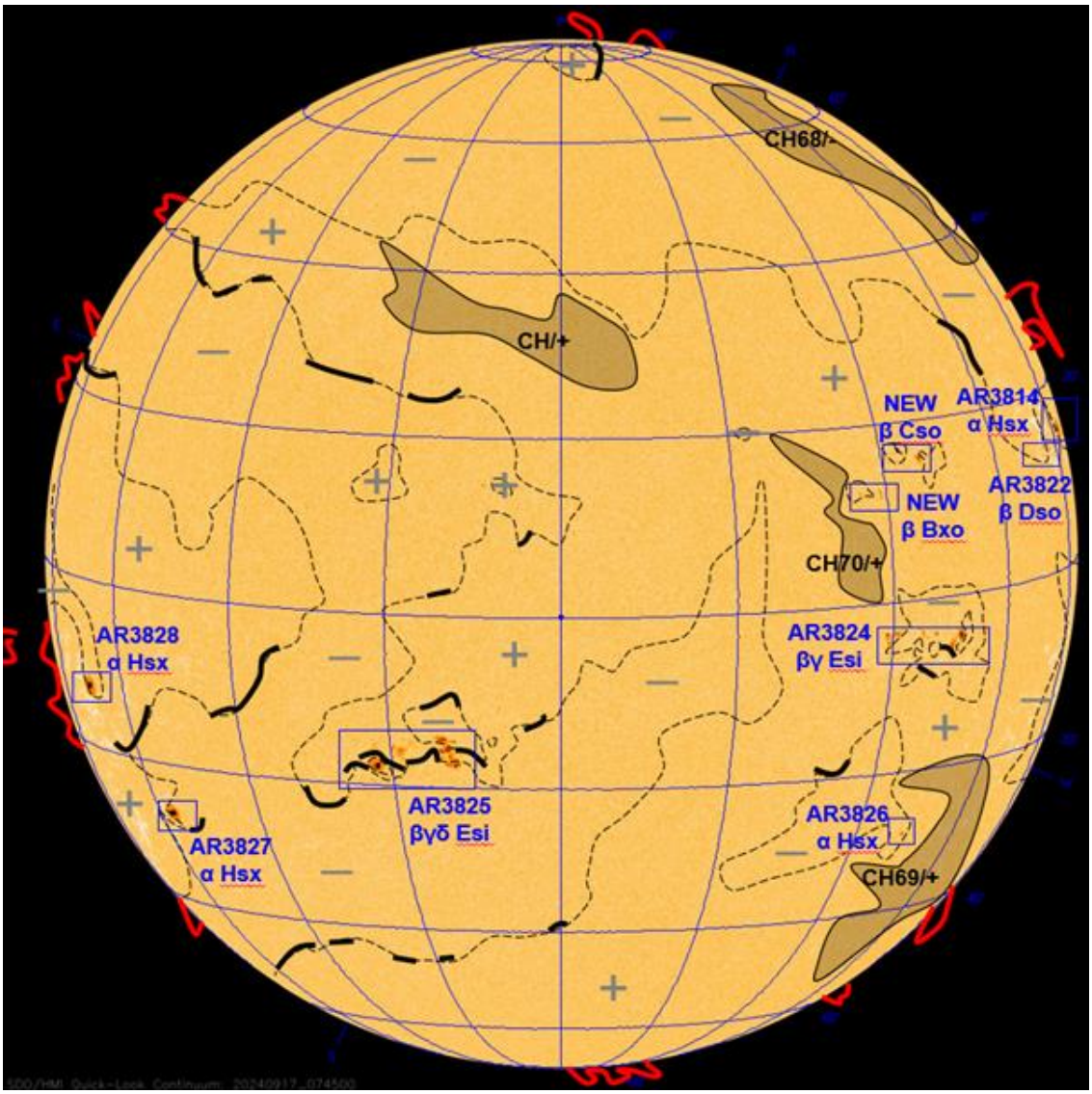
Figure 1. Solar Analysis Valid 17/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME arrived at L1 at 16/2250UTC and observed as an impulse on BGS Magnetometers around 17/0130UTC. This is considered to comprise of up to two CMEs, but with the majority of the contribution from the CME that left the Sun on 14 Sep associated with the X4.5 flare from AR3825. A CME from 13/0930UTC from an M2.9 flare from AR3814 may also have been swept up in this CME arrival. ACE EPAM LEMS showed a very slight rise prior to this arrival, however the lead time was very short (tens of minutes). The resultant response in Geomagnetic Activity was a peak G4/Severe Geomagnetic Storm (Kp 8) interval before gradually declining to current G1/Minor Geomagnetic Storm levels (Kp 5). There remains a chance of G2/Moderate Geomagnetic Storming (Kp 6) during the UTC afternoon and non-nil risk of G3 (Kp 7), however this is considered a very low probability given the lack of further arrivals. Enhancement is then expected to wane, with activity trending towards Unsettled to Active (Kp 3-4) through Day 1 and into Day 2 (18 Sep).

The fast wind forecast is probably of lesser consequence. A positive fast wind is perhaps now considered to already be in evidence and CH69/+ may have arrived as early as Saturday 14 September. A second small small positive coronal hole near centre disc (CH70/+) may bring further Slightly Elevated to Elevated wind speeds at Earth for a time later Day 2 and into Day 3 (19 Sep), prolonging a Slight Chance of G1 before waning to leave Quiet (Kp 0-2) conditions later in the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	100	20	10	1
Strong	G3	Yes	5	1	1	1
Severe	G4	Yes	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

No further CME arrivals are currently expected.

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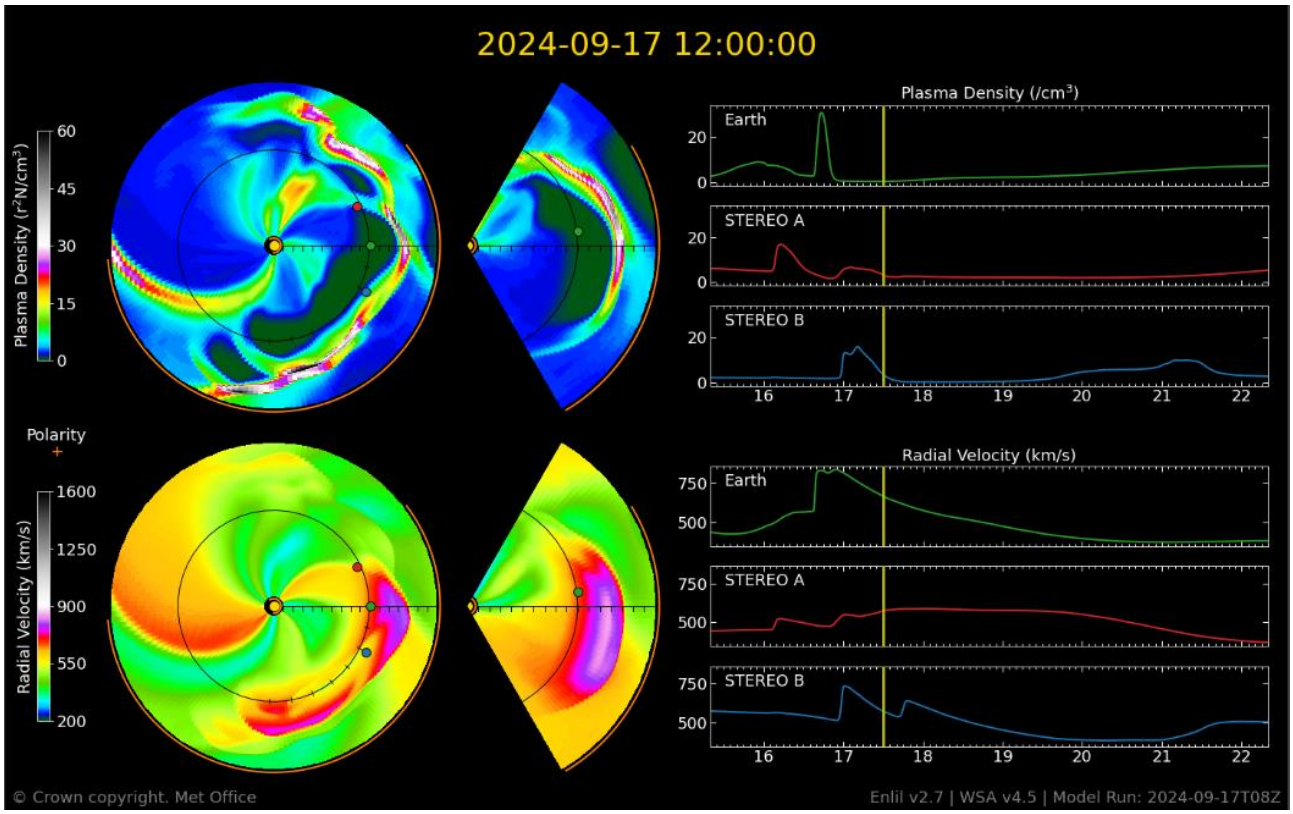
Figure 2: MOSWOC Enlil – wind speeds currently too high.



Radio Blackouts - X-Ray Flares:

There are currently nine sunspot regions on the Earth-facing disc, two of which are of significance to the flare forecast. AR3825 (Esi/Beta-Gamma-Delta), in the southeast, remains the largest and most complex of regions on the disc and has seen the emergence of a delta configuration on its trailing portion during 17 Sep. AR3825 remains perhaps the most noteworthy group for the forecast period due to its history of X-class activity. Also of note is AR3824 (Esi/Beta-Gamma) in the southwest. This region continues to evolve, with proliferation and consolidation of spots in its lead portion and signs of a weak delta region possibly forming on the trailing portion.

Both of these dominant regions remain on the disc for almost the entire four days, with AR3824 reaching the limb by the end of the UTC working week on Day 4 (20 Sep). No significant regions are expected over the eastern solar horizon in the same interval, and the daily risk of flares is therefore held constant throughout.

Overall, the chance of M-class flares is maintained with a slight chance of X-class flares. The X-class level is above raw probabilities due to recent history of X-class activity from AR3825.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)

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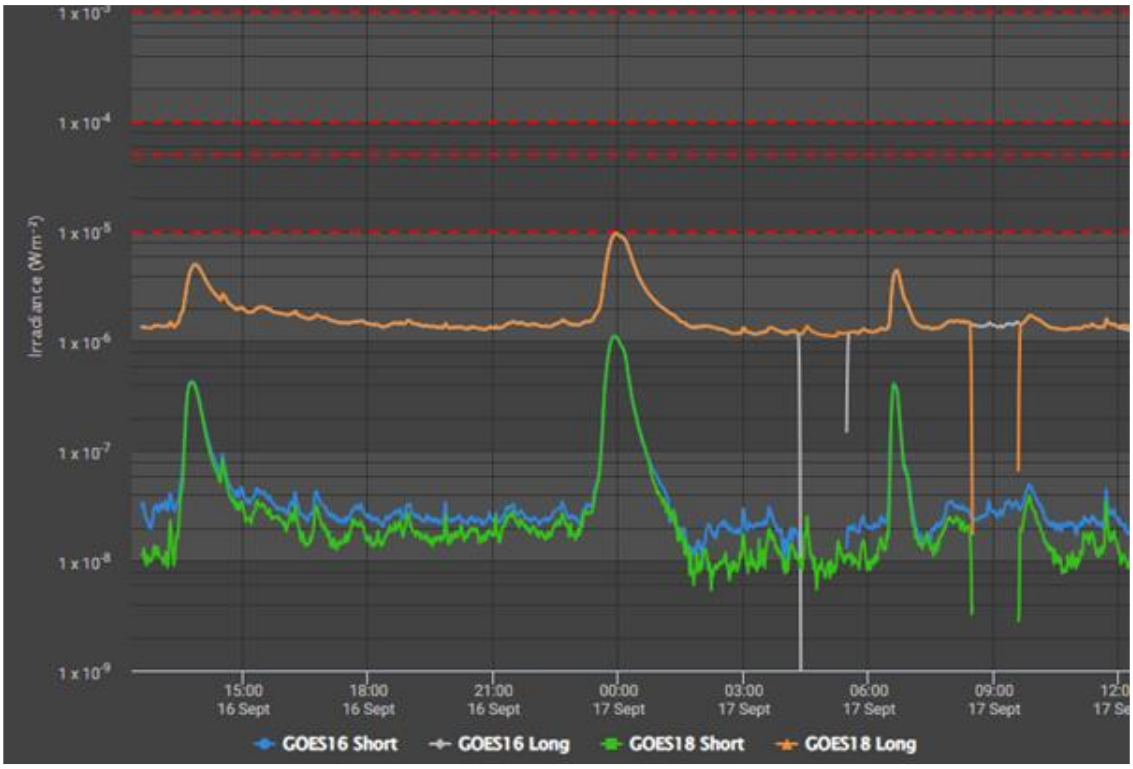
Active	**R1-R2 M Class**	No	40	40	40	40
Very Active	**R3 to R5 X Class**	No	10	10	10	10

Figure 3: GOES16 and GOES18 X-Ray trace over last 24 hours.



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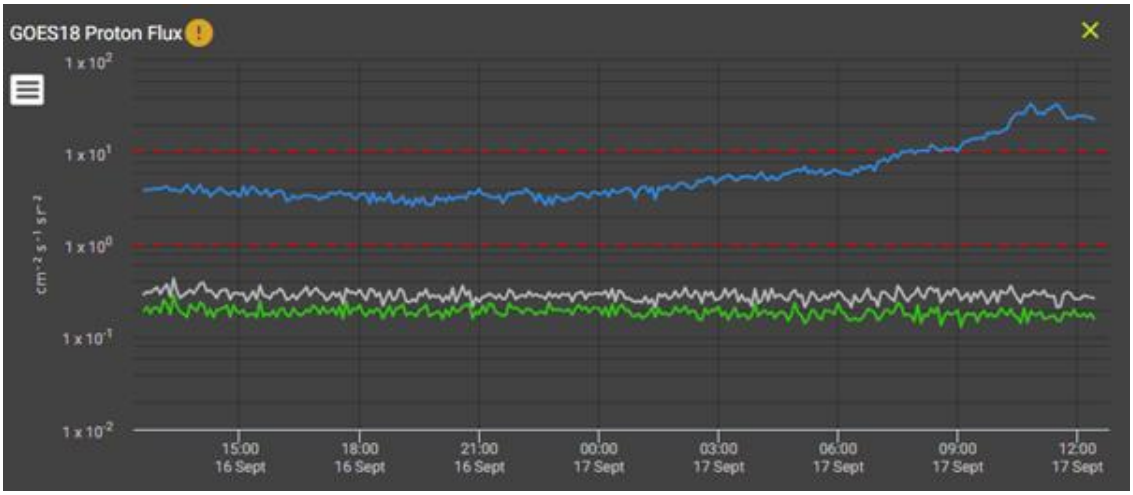
Solar Radiation Storms - (High Energy Protons):
High energy proton flux at GOES18 has been above resting background levels since the X4.5 flare from AR3825 on 14 September. Levels rose to S1/Minor Solar Radiation Storm around 17/0725 UTC and have continued to rise. There is a slight chance through Day 1 that levels may rise to S2/Moderate Solar Radiation Storm but this is considered a low probability. There is a chance of new enhancements during the forecast period, this would be more likely from AR3824 given its more favourable position in the western solar hemisphere, but AR3825 in the southeast may also act as a source in the event of any significant activity, having previously produced a proton response.

High energy proton flux levels are expected to peak at S1 on Day 1 (17 Sep) before waning during Day 2 (18 Sep) and returning to background Days 3-4. The slight chance of S1 later in the period takes into consideration the potential for enhancement from AR3824 and/or AR3825.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	100	40	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES18 Proton Flux levels



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High Energy Electrons Event (≥ 2MeV):

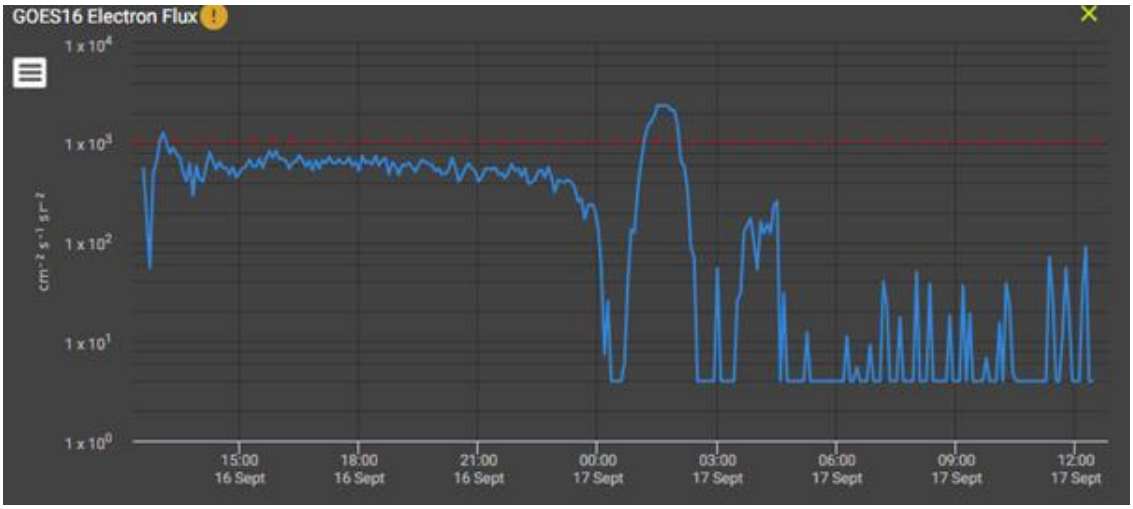
High energy electron flux is currently at background following the arrival of the CME arrival late on 16 Sep. Flux levels at GEO are displaying apparent suppression, although a rebound is anticipated later in the coming UTC week. The recovery in flux levels and charging associated with the CME arrival may see the return to a diurnal variation of background to moderate, perhaps peaking at high during diurnal maximum.

The anticipated onset of a fast wind from CH70/+ during 18-19 Sep is not expected to influence the forecast greatly, but there is a slight chance that it may act to further suppress and delay the electron flux recovery.

The forecast is therefore uncertain, but should continue to exhibit a suppression and then rise to a stable elevated level. This is represented by variations on a Slight Chance throughout. MOSWOC REFM is not considered to be useful in this instance given the dominance of a CME in the forecast outcome.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	1	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: GOES16 Electron Flux levels



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